AN EMPIRICAL SIMULATION ANALYSIS OF COTTON MARKETING STRATEGIES IN WEST TEXAS

A Thesis

by

CHRISTOPHER PATRICK ELROD

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

December 2008

Major Subject: Agricultural Economics

AN EMPIRICAL SIMULATION ANALYSIS OF COTTON MARKETING STRATEGIES IN WEST TEXAS

A Thesis

by

CHRISTOPHER PATRICK ELROD

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

Approved by:

Chair of Committee,	James W. Richardson
Committee Members,	John R. C. Robinson
	David P. Anderson
	F. Michael Speed
Head of Department,	John P. Nichols

December 2008

Major Subject: Agricultural Economics

ABSTRACT

An Empirical Simulation Analysis of Cotton Marketing Strategies in West Texas.

(December 2008)

Christopher Patrick Elrod, B.S., California Polytechnic University, San Luis Obispo

Chair of Advisory Committee: Dr. James Richardson

The three marketing strategies, buying a put option, cash sale at harvest, and cash sale in June after December harvest, are simulated for six representative irrigated and dryland cotton farms in West Texas. Each marketing strategy is ranked using the net cash income probability distribution for the representative farms using stochastic efficiency with respect to a function (SERF).

SERF rankings were consistent across dryland and irrigated farms. The buying of a put option was found to be the marketing strategy that produced the highest certainty equivalent (CE) for normal risk averse decision makers. Cash sale at harvest followed by cash sale in June marketing strategies were ranked second and third, respectively. A sensitivity analysis increased the national baseline price used in the model by 45 percent. Cash sale at harvest then consistently became the highest ranked marketing strategy followed by buying a put option and then cash sale in June. The research found that if a strike price and premium that covered the production costs of the representative farm was available during the pre-harvest period, the decision maker may have the ability to increase utility by hedging with the put option.

DEDICATION

To Terry Elrod, Bill Elrod, Jim Elrod, Elaine Elrod, Chuck Parker, and Margaret Parker

ACKNOWLEDGEMENTS

I would like to thank Dr. Robinson and my committee chair, Dr. Richardson, for their support and guidance with my research. I would like to extend my gratitude to Dr. Anderson and Dr. Speed for allowing me to have them on my committee. Special thanks to Caroline Gleaton and Vicki Heard for the assistance they have given me through my stay at Texas A&M. Finally, I would like to thank my mother and father for all the support they have given me throughout my life.

TABLE OF CONTENTS

Page

LIST OF FIGURES

Page

LIST OF TABLES

Page

CHAPTER I

INTRODUCTION

Cotton accounts for 40 percent of total fiber production in the world. The United States is the third largest producer of cotton and is the largest exporter of the fiber. China, India, and the United States provide over half of the cotton supplied to the world while the United States alone accounts for one third of the total cotton exported to the world. Domestically, cotton is a $25 billion industry where Texas is the largest cotton producing state with production concentrated in the west Texas High Plains (USDA-ERS 2008). Before the majority of cotton in this region is produced, the cotton farmers generally decide how to market their cotton.

Cotton producers have a number of ways of marketing their product which include forward pricing, sale at harvest, or storage for deferred sale. The relevance of forward pricing has been questioned in light of presumed efficient commodity markets (Zulauf and Irwin 1998). However, both past and recent evaluations of cotton market efficiency, while indicating long-run efficiency, still highlight seasonal opportunities for hedging higher pre-harvest prices than at harvest time (Curtis, Hummel, and Isengildina-Massa 2007; Chavez, Robinson, and Salin 2007; Kolb 1992). A common method of marketing U.S. cotton is through the Commodity Credit Corporation (CCC) loan program. The CCC loan program is often used in combination with other marketing outlets. High market prices, however, may diminish the relevance of the CCC loan

---

This thesis follows the style of the *Journal of Agricultural and Applied Economics*.

program. With several marketing strategies available for the sale of cotton, the question remains, which alternative will be preferred by risk averse decision makers (DM)?

The objective of the study was to identify risk efficient marketing strategies for a representative west Texas High Plains cotton farm. To accomplish this, the study ranked the net cash income probability distributions for alternative marketing strategies using stochastic efficiency with respect to a function to identify the preferred alternative marketing strategy for risk averse DM's. A Monte-Carlo simulation model was used to estimate the net cash income probability distributions for: 1) forward pricing with put options, 2) selling the crop at harvest using spot price cash sale, and 3) selling the crop in June of following year using spot price cash sale on a representative cotton farm.

The research tested a refutable hypothesis that forward pricing in cotton maximizes utility for all risk averse DM's as compared to selling at harvest in the local cash market at harvest (November-December) or selling in the cash market in June of the following year. In addition, the analysis evaluated the relative risk efficiency of these marketing alternatives. The analysis looked forward one year for a representative farm. Three marketing strategies were tested over six irrigated and dryland farms with varying cotton production risk.

CHAPTER II

LITERATURE REVIEW

Futures markets exist for securities, foreign currency, or any commodity that has enough market participants who want to exchange price risk. The market participants consist of hedgers and speculators. Hedgers reduce price risk by guaranteeing future prices for products closely related to the commodity associated with their business. Speculators absorb the hedger's price risk in an attempt to predict the market and make a profit (Kidwell *et al.* 2006). Cotton producers and cotton marketing cooperatives commonly sell futures contracts as hedgers to reduce price risk for the cotton they have or plan to have in the future. A cotton merchant may also hedge by selling a futures contract for the commodity to hedge his profit margin. The constant influx of information provided to the market by speculative trade supports efficiency within the market.

Options exist as derivatives of cotton futures contracts. An option contract allows the holder of the contract to buy the right to buy (call option) or to sell (put option) at a predetermined strike price prior to the future contract's expiration. The price of the option is the premium charged by the seller of the option to compensate for the assumed price risk. Whether an option is "in" or "out" of the money is defined by the existence of intrinsic value or the value in exercising the option. If intrinsic value exists, the option becomes "in the money," thus if no intrinsic value exists the option is "out of the money," (Kidwell *et al.* 2006).

In commodity markets, weak form market efficiency exists when all historical data is reflected in the current price of that commodity (Tomek 1997). The ability to forward price allows a cotton marketer to lock in a price which provides protection from future price movement. The question is whether opportunities in the cotton market present themselves so forward pricing is feasible in an efficient market environment.

Researchers have found cotton cash and futures markets demonstrating inefficiencies at times. Brorsen, Bailey, and Richardson (1984) found cotton cash market price movement was a determinant of futures market movement. The study also found that between 1976 and 1982 market inefficiencies existed. Wood, Shafer, and Anderson (1989) observed opportunities for profitability in hedging margins for cotton during pre-harvest periods in the west Texas High Plains region from 1980 through 1986.

More recent studies have suggested that hedging strategies in the cotton market have shown seasonality and an opportunity for capturing a profit. Zulauf and Irwin (1998) showed that, “For cotton, significant returns are found only when hedgers are net short for the entire month prior to the position being taken.” This may suggest that a risk factor could exist for cotton that makes limited seasonal hedging a relevant strategy. Other researchers have studied specific times of year for the best time to forward contract for December cotton futures contracts. For example, Curtis, Hummel, and Isengildina-Massa (2007) examined seasonal patterns for December cotton futures. Using a form of the Black-Scholes model, their study identify early March as the optimal time for pre-harvest hedging with put options. Their results reflected a trade-off between longer time value and relatively low volatility of December options at that point in time.

The efficient market hypothesis underlies the argument for cash sale at harvest. The efficiency of the market is demonstrated by a “random walk” of prices over time. An efficient market’s best forecaster of tomorrow’s price is the price today as all publicly available information is obtainable to participants in the market. This description of efficient markets makes future prices for commodities, like cotton, difficult to predict. Forward pricing is therefore seen as challenging at best, and perhaps futile. Futures markets have been shown to have varying forecast ability depending on the observed efficiency of the market. Where markets are shown to be more efficient, a model’s forecast ability is reduced and does not show much consistent accuracy at predicting actual futures price (Zulauf and Irwin 1998). In applying a cash sale at harvest market strategy, the cotton marketer is content with absorbing the risk associated with taking a price during the harvest season.

Simulation allows one to estimate the probability distribution for risky alternatives. This study applied a Monte Carlo budget simulation model to evaluate three alternative cotton marketing strategies using net cash income per acre for one year as the estimated key output variable (KOV). Meyer (1977) and Bailey and Richardson (1985) demonstrated the use of stochastic dominance to rank risky alternatives. However, this method of ranking alternatives incorporates a large range of risk aversion levels for a DM. This often makes ranking unclear as to which risky alternative is dominant and is limited by comparing pairwise combinations (Richardson and Outlaw 2008).

Hardaker *et al.* (2004) introduced stochastic dominance with respect to a function (SERF) to allow risk rankings over a wide range of DM's. By using a lower relative risk aversion coefficient of zero and an upper risk aversion coefficient (RAC) for extremely risk averse DM's, SERF is able to rank risky alternatives across all risk averse DM's. SERF calculates the certainty equivalent (CE) for a given utility function at all RAC levels from zero to the upper RAC, for each risky alternative. A CE for a risky outcome is the return for a definite result as compared to an uncertain lottery. Hardaker *et al.* (2004) showed that using a CE to rank risky alternatives is equivalent to ranking based on utility functions, but does not require calculating the DM's RAC. Like utility maximization, when ranking risky alternatives using SERF, the alternative with the highest CE at a given RAC is preferred for all DM's who have a RAC at that level. By calculating CE's for all RAC's, SERF is able to show the preferences among many risky alternatives over the relevant spectrum of risk averse DM's.

Previous economic models have used different methods and KOV's to rank marketing strategies. Bailey and Richardson (1985) used a detailed whole-farm Monte Carlo simulation model to rank a Texas High Plains cotton farm's net worth using stochastic dominance set within the parameters of alternative marketing strategies over a 10 year planning horizon. Coble, Zuniga, and Heifner (2003) simulated net return probability distributions to analyze marketing strategies for cotton and soybean producers. Lein *et al.* (2007) simulated probability distributions for the net present value of stands of trees. Using SERF, the study ranked risky alternatives taking into account the DM's degree of risk aversion for reinvestment in the forestry industry. Richardson *et al.* (2007) used whole farm simulation and SERF analysis to compare risky alternatives for Dutch dairy farmers. Whole farm analysis incorporates all financial statements while making variables within the financial statement stochastic. This aids in incorporating risk in long term decision making by including cash flow, balance statements, and current and future budgeting. Following Richardson and Bailey (1985), Barham (2007) used a Monte Carlo budget simulation model to simulate net cash income per acre for one year as the KOV for a Texas Lower Rio Grande Valley cotton farm.

Past studies have shown Monte-Carlo simulation as being an accepted methodology for estimating probability distributions of net cash income for alternative management scenarios. SERF has also been shown take an accepted method to rank probability distributions of net cash income for alternative management scenarios. The model developed by this study implements both of these methods to identify the most risk efficient marketing strategy for a representative west Texas High Plains farm.

CHAPTER III

METHODS

A Monte-Carlo simulation model was used to evaluate marketing strategies for irrigated and dryland representative cotton farms in the west Texas High Plains. The model incorporated costs and yields associated with each production system. Yield and price variables were made stochastic. The budget simulation model used cost, price, and yield data to calculate the KOV net cash income. This chapter describes the method used to estimate the probability distributions of net cash income per acre for three marketing strategies: 1) forward pricing (hedge) strategy, 2) cash sale at harvest, and 3) cash sale in June after harvest.

Stochastic yields were simulated for six yield risk scenarios based on historical cotton yields from west Texas High Plains irrigated and dryland farms. Each of the six representative yield risks was treated as a separate farm. The three marketing strategies were all subject to the same six yield risk scenarios, thus producing 18 scenarios. The historical yields showed no trend, so the historical mean became the deterministic forecasted yield. The stochastic yield was simulated assuming empirical (Emp) probability distributions. The representative farm's mean yield multiplied by one plus Emp percent deviate from mean equaled the stochastic yield (Equation 1).

(1) Stochastic Yield = Historical Yield Mean * (1 + Emp(.))

Stochastic national market price was simulated based on a historical national market price projection. The Food and Agricultural Policy Research Institute (FAPRI) national price baseline forecast for 2007, 52 cents/lb., was the deterministic forecast for national market price. No trend was found in any of the cotton price data. To account for the correlation among the price variables, a multivariate empirical probability distribution (MVEmp) was used to simulate national market price, November basis, and June basis (Richardson *et al.* 2000). MVEmp was also used because the small sample (1997-2007) data set did not allow for adequate testing of normality. Each marketing strategy used the same national market price. The stochastic forecast for national price was 52 cents/lb. multiplied by one plus the MVEmp stochastic national price percent deviate from mean (Equation 2).

(2) Stochastic National Market Price = 0.52 * (1 + MVEmp(.))

Stochastic Lubbock Texas spot price for November and June was simulated using an ordinary least squares (OLS) equation of Lubbock spot price as a function of the national market price (Bailey and Richardson 1985). The Lubbock spot price for November was used in the hedge and cash sale at harvest marketing strategies while Lubbock spot price for June was used in the cash sale in June marketing strategy. Stochastic Lubbock spot price for November and June equaled the intercept from the OLS regression for November or June Lubbock spot (a_1) plus November or June Lubbock spot coefficient (β_1) multiplied by the stochastic national price (Equation 3).

(3) Stochastic Lubbock Spot = $a_1 + \beta_1$ * Stochastic National Price

A similar equation was used to estimate adjusted world price (AWP). November and June AWP were simulated using an OLS equation where AWP was a function of national cotton market price. AWP is the prevailing world price for upland cotton and is used by the model to calculate loan deficiency payments (LDP). November and June AWP were estimated as the intercept from the OLS regression for November or June AWP (a_2) plus November or June AWP coefficient (β_2) multiplied by stochastic national price (Equation 4).

(4) Stochastic AWP = $a_2 + \beta_2$ * Stochastic National Price

The basis simulated for November (using December futures contract) and June (using July futures contract) used the historical futures and Lubbock spot price in 1997-2006 for November and 1998-2007 for June. The basis was calculated by subtracting Lubbock spot by the corresponding futures price on the same trading day. The historical means for November and June basis were used as the deterministic forecast which was multiplied by one plus the stochastic deviate for November or June basis deviates. The model's stochastic basis was subtracted from the stochastic Lubbock spot price to calculate the stochastic futures price (Carter 2003). Stochastic November and June basis equals historical basis mean multiplied by one plus the stochastic MVEmp basis percent from the mean deviate (Equation 5).

(5) Stochastic Basis = Historical Basis Mean * (1 + MVEmp (.))

November futures price for a December contract and June futures price for a July contract were then calculated from stochastic Lubbock spot price and stochastic basis. Stochastic November or June futures price equals the stochastic Lubbock November or June spot price minus the stochastic November or June basis (Equation 6).

(6) Stochastic Futures Price = Stochastic Spot Price – Stochastic Basis

Intrinsic value was calculated for a put option by subtracting harvest time futures price from the strike price (Equation 7). The model assumed a 65 cents/lb. strike price per cotton contract. A negative intrinsic value indicates no intrinsic value.

(7) Stochastic Intrinsic Value = max [(0.65 – Stochastic Futures Price) , 0]

Market receipts for cash sale in Lubbock were estimated based on the stochastic yield multiplied by the stochastic Lubbock spot price (Equation 8). The hedge and cash sale at harvest marketing strategy used November Lubbock stochastic spot price while cash sale in June used June Lubbock stochastic spot price.

(8) Market Receipts = Stochastic Yield * Stochastic Spot Price

Government support payments were included in each marketing strategy. The government support was provided in the form of direct payments (DP), counter cyclical payments (CCP), and loan deficiency payments (LDP) for producers. A DP equaled 85 percent of historical base acres (BA) for a farm and multiplied by the direct payment rate and a fixed direct payment yield (USDA 2007) (Equation 9).

(9) DP = 0.85 * BA * DP Yield * DP Rate

CCP's were calculated from a CCP yield multiplied by a CCP rate, CCP yield, and base acres. The payment rate was determined using the fixed target price (TP). This target price minus the DP rate is compared to the season average price received for cotton. If the season average price received for cotton falls below the target price minus the DP rate, a CCP was made based on the TP minus the DP less the national price (NP) or loan rate (LR) rate and multiplied by 85 percent of BA and CCP yield (Equation 10).

If the season average price rises above the TP minus DP rate, then no payment was received (Monke 2004).

(10) CCP = ((TP - DP Rate) -MAX (LR or NP)) * 0.85 * BA * CCP Yield

LDP payment was calculated from a legislatively set loan rate and AWP. If the loan rate set at 52 cents/lb. per pound by the government is higher than the AWP, then the difference is claimed by the producer (Equation 11). Payment is only claimed if a positive value is calculated. This government payment differed between November and June due to different AWP's.

(11) LDP = (0.52 – Stochastic AWP)* Stochastic Yield

Total government payments equaled DP plus CCP plus LDP (Equation 12).

(12) Total Government Payments = DP + CCP + LDP

Option gains or losses only applied to the hedging strategy. The premium or cost assumed for the 65 cents/lb. strike price was a three cents/lb. The strike and premium price for the put option are critical as these prices determine the value of the forward pricing strategy. Eleven out of twenty-one years analyzed (1987-2007 January-June) found at least one or more 'out of the money' put options trading with a strike price at 65 cents/lb. with less than a three cents/lb. premium. The strike and premium price were exogenous variables based on a breakeven value that is near cost of production for the budgets of the representative farms. The amount hedged was equal to the historical average of cotton yields for the representative farm. Option gains depend on the existence of intrinsic value. With a positive intrinsic value, option gains equal historical yield multiplied by intrinsic value (Equation 13).

(13) Stochastic Option Gains = Historical Yield * Stochastic Intrinsic Value

Total receipts were different among the marketing strategies. The hedge marketing strategy included option gains, while cash sale at harvest and cash sale in June had zero option gains. The hedge and cash sale at harvest marketing strategies use November Lubbock simulated spot price, and the cash sale in June marketing strategy uses June Lubbock simulated spot price. Total receipts equaled total government payments (GP) plus market receipts plus option gains (Equation 14).

(14) Total Receipts = GP + Market Receipts + Option Gains

Option cost was included only for the hedge marketing strategy. The cost of purchasing the option was calculated by multiplying a representative farm's average historical yield by the assumed three cents/lb. option premium (Equation 15).

(15) Option Cost = Historical Yield * 0.03

Each marketing strategy used the same crop budget for dryland and irrigated cotton (Table 1). West Texas High Plains farm budgets located in the study area (Texas Extension Districts 1 and 2) for irrigated and dryland were used to estimate direct and fixed cost for the model (Texas Agrilife Extension Service 2007). Variable cost was made stochastic due to the variable nature of yield in the model. Ginning and harvest costs are simulated by multiplying stochastic yield by the per pound cost of these expenses.

Table 1. Budgets for Dryland and Irrigated West Texas High Plains Farms

Irrigated					Dryland				
Direct Expenses	UNIT	Price	Quantity	Amount	***Direct Expenses***	UNIT	Price	Quantity	Amount
Seed- cotton	lb.	2.40	15.00	36.00	Seed- cotton Dryland	lb.	0.60	12.00	7.20
seed treatment	acre	12.00	1.00	12.00	*Fertilizer*				
Fertilizer					Fert-(P)	lb.	0.30	20.00	6.00
Fert-(P) - Dry	lb.	0.30	25.00	7.50	Fert-(N)	lb.	0.35	30.00	10.50
Fert-(N) - Dry	lb.	0.35	100.00	35.00	*Custom*				
Custom					Preplant Herb + appl	acre	12.00	1.00	12.00
Fert appl- dry	acre	4.50	1.00	4.50	Fert appl- dry	acre	4.50	1.00	4.50
Preplant Herb + appl	acre	12.00	1.00	12.00	Hoeing- dry cotton	acre	12.00	1.00	12.00
Post emerg herb + appl	acre	16.00	1.00	16.00	Insec + appl	appl	12.00	0.50	6.00
Insec + appl	appl	12.00	1.00	12.00	Harvaid apply- cot dry	acre	20.00	0.50	10.00
Harvaid apply- cot dry	acre	25.00	0.75	18.75	Strip & module	cwt.	1.45	1.17	1.70
Strip & module	cwt.	1.45	6.89	9.99	Ginning	cwt.	2.40	1.17	2.82
Ginning	cwt.	2.40	6.89	16.53	Crop Insurance	acre	12.25	1.00	12.25
Crop Insurance	acre	20.00	1.00	20.00	Boll Weevil Assess	acre	6.00	1.00	6.00
Boll Weevil Assess	acre	12.00	1.00	12.00	Operation Labor Implements	hour	9.10	1.19	10.85
Operation Labor Implements	hour	9.10	1.06	9.63	Operation Labor Tractors	hour	9.10	1.16	10.54
Operation Labor Tractors	hour	9.10	1.08	9.87	Hand Labor Implements	hour	9.10	0.15	1.39
Hand Labor Implements	hour	9.10	0.19	1.74	Diesel Fuel- Tractor	gal	2.00	5.13	10.25
Diesel Fuel- Tractors	gal	2.00	4.85	9.71	Gasoline- Pickup	gal	2.25	2.01	4.52
Gasoline- Pickup	gal	2.25	3.52	7.91	*Repair & Maint.*				
Irrigation Energy Center Pivot	ac-in	8.30	12.00	99.60	Implements	acre	13.77	1.00	13.77
Repair & Maint.					Tractors	acre	12.42	1.00	12.42
Implements	acre	12.45	1.00	12.45	Pickup	acre	0.16	1.00	0.16
Tractors	acre	11.77	1.00	11.77	Intrest on Op. Cap.	acre	12.39	1.00	12.39
Pickup	acre	0.28	1.00	0.28					
Center Pivot	ac-in	2.03	12.00	24.36	***Fixed Expenses***				
Intrest on Op. Cap.	acre	31.97	1.00	31.97	Implements	acre	24.41	1.00	24.41
					Tractors	acre	20.90	1.00	20.90
Fixed Expenses					Pickup	acre	0.30	1.00	0.30
Implements	acre	22.35	1.00	22.35					
Tractors	acre	19.94	1.00	19.94	*Allocated Cost Items*				
Pickup	acre	0.54	1.00	0.54	Cash rent- cottonland	acre	15.00	1.00	15.00
Center Pivot	ac-in	33.60	1.00	33.60					
Allocated Cost Items									
Cash rent- cottonland	acre	45.00	1.00	45.00					

Source: Texas Agrilife Extension Service (2007)

Operating interest is the only interest cost included for the model. Operating interest cost varies between the cash sale in June marketing strategy and the other marketing strategies. An assumed eight percent operating interest rate was used. The June marketing strategy extended the operating loan for six months and was incorporated by adding the interest expense to the June marketing strategy's operating interest cost. Operating interest cost was calculated by multiplying direct expenses for each production method by eight percent for one year (Equation 16). In the June marketing strategy, the operating loan was for 1.5 years so the effective interest rate was 12 percent.

(16) Operating Interest Cost = Direct Expenses * 0.08

Total cost was calculated by summing direct expenses, fixed cost, option cost and interest cost (Equation 17).

(17) Total Cost = Direct Expenses + Fixed Cost + Option Cost + Interest Cost

Net cash income per acre is calculated by subtracting total cost from total receipts (Equation 18). All costs and receipts were estimated on a per acre basis. Calculating net cash income per acre is the KOV used by the simulation model.

(18) Net Cash Income = Total Receipts – Total Cost

The simulation model used the stochastic variables and rules for programming marketing strategies to simulate net cash income per acre. The pre-harvest hedge marketing strategy involved purchasing a put option during the period of time before harvest between January and June strike price and premium set as fixed parameters. The model was designed to be updated yearly for extension education with exogenous option strike and premium prices reflecting pre-harvest market conditions, costs, and government payments.

The option position was evaluated depending on stochastic harvest period of futures price. Higher futures prices forced the model to sell the put option. If there was no intrinsic value, the resulting loss equaled the expiring option premium multiplied by the amount hedged. If there was intrinsic value, the resulting gain equaled the expiring option premium value multiplied by the amount hedged. To be precise, if there was intrinsic value greater than three cents, then the resulting gain would equal the strike price less harvest futures price and three cents. This result would then be multiplied by the amount hedged. Time value is assumed to be non-existent because the put is offset at its expiration. Option value related to volatility is assumed to be negligible in November. The amount to be hedged was determined by the expected yield based off the historical yield of the representative farm. The calculated stochastic yield was sold on the spot market in the month of November.

The cash sale at harvest marketing strategy involved selling the crop on the spot market in November. The cash sale in June marketing strategy required storing the crop in the CCC loan program until June after harvest. Additional storage costs for the cash sale in June strategy were incorporated into the model. Each of these strategies sold at the Lubbock spot price for the corresponding month.

CHAPTER IV
DATA ANALYSIS

Historical prices and yield data and projected budgets provided the data for the present study. The Texas Agrilife Extension Service (2007) publishes expected fixed and variable costs associated with irrigated and dryland west Texas high plain farms. The fixed and variable costs for farms in this region were used to simulate costs of production for the representative farms. Actual historical yields and historical data (1997-2007) for daily cotton futures settlement prices, historical local Lubbock spot price, and historical adjusted world price (AWP) were used to estimate parameters for simulating stochastic variables.

Yield Data

Actual historical yields were provided for Financial and Risk Management (FARM) Assistance cotton farms in the study area. FARM Assistance is a whole-farm decision support system for Texas farmers and producers. Using production and cost data provided by farmers, FARM Assistance aids producers with long-term strategic planning decisions (Klose 2007). A sample of 351 irrigated and dryland cotton farms were collected from USDA-NASS District 1-S and 1-N from FARM Assistance (Figure 1). Of the 351 farm yields, thirteen irrigated and five dryland farm yields were identified as having had complete yield histories from 1997-2006. Three irrigated farms and three dryland farms were selected from the sub sample based on their historic coefficient of variation (CV) for yield over ten years.

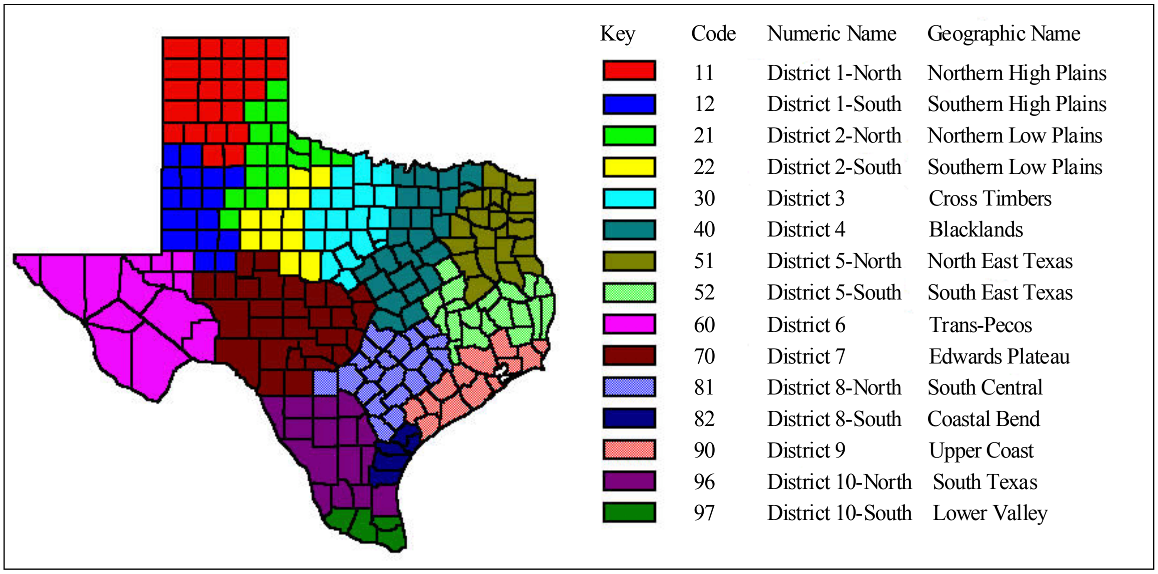

Figure 1. Agricultural District Map for the State of Texas
Source: USDA-NASS (2008)

The summary statistics were calculated for the thirteen irrigated and five dryland farm yield's CV's. The farm whose yield had the median CV was selected to represent the medium representative yield variability scenario. The lower yield variability scenario farm was selected as the farm whose CV was closest to one standard deviation below the median CV farm. The high yield risk variability scenario farm was picked as the farm whose CV was closest to one standard deviation above the median CV farm. This process was repeated for both dryland and irrigated farms.

The irrigated farm yield CV data had a median of 36.27 with a standard deviation 12.37. Farm 7 represents the irrigated medium yield risk scenario with a CV of 36.27 (Table 2). Irrigated Farm 12 represents the irrigated high yield risk scenario with a CV of 44.97, and with a CV of 26.28, irrigated Farm 1 represents the irrigated low risk yield scenario (Table 2). The sample dryland farm yield data had a median CV of 83.85 and a standard deviation of 5.72 (Table 2). Dryland Farm 3 represents the dryland medium yield risk scenario with a CV of 83.85. Dryland Farm 5 represents the dryland high yield risk with a CV of 91.44 and the dryland low yield risk scenario is represented by Farm 1 with a CV of 75.40 used by the model (Table 2).

Table 2. Summary Statistics for Farms' Yield Coefficient of Variation

Irrigated	CV	Dryland	CV
Farm 1	26.28	Farm 1	75.40
Farm 2	27.15	Farm 2	83.58
Farm 3	29.71	Farm 3	83.85
Farm 4	33.58	Farm 4	85.16
Farm 5	34.86	Farm 5	91.44
Farm 6	36.14		
Farm 7	36.27	Mean	83.89
Farm 8	37.36	StDev	5.72
Farm 9	38.01	Min	75.40
Farm 10	38.28	Median	83.85
Farm 11	41.21	Max	91.44
Farm 12	44.97		
Farm 13	75.66		
Mean	38.42		
StDev	12.37		
Min	26.28		
Median	36.27		
Max	75.66		

Table 3 summarizes the historical yields for the six farms selected to represent low, medium, and high yield variability. The irrigated farms had lower yield CV's and higher average yields. The dryland historical yield data show high yield CV's with much lower average yields. As expected, dryland farming inherently has more yield risk due to reliance on weather conditions to supply water.

Table 3. Irrigated and Dryland Historical Farm Yields and Summary Statistics

Irrigated				Dryland			
Years	High CV	Medium CV	Low CV	Years	High CV	Medium CV	Low CV
1997	838	1053	1081	1997	54	243	163
1998	684	918	391	1998	174	264	324
1999	705	1135	1221	1999	254	7	138
2000	473	792	1058	2000	0	0	0
2001	628	427	1015	2001	54	63	136
2002	839	729	968	2002	4	0	0
2003	1183	1099	1463	2003	182	130	264
2004	0	306	1020	2004	170	133	198
2005	1018	560	1265	2005	106	248	326
2006	965	830	1197	2006	426	263	501
Mean	708	780	1054	Mean	142	135	205
StDev	339	300	294	StDev	130	113	155
95 % LCI	404	511	791	95 % LCI	34	41	76
95 % UCI	1011	1049	1316	95 % UCI	251	229	334
CV	48	39	28	CV	91	84	75
Min	0	306	391	Min	0	0	0
Median	705	792	1058	Median	138	132	181
Max	1183	1135	1463	Max	426	264	501
Skewness	-0.932	-0.361	-1.324	Skewness	1.091	-0.046	0.439
Kurtosis	1.812	-1.265	3.480	Kurtosis	1.377	-1.948	0.128

Note: Six historical yields used by the simulation model.
Source: Klose (2007)

The yield data from the six farms (i.e., high/medium/low yield variability scenarios for irrigated and dryland) were used to estimate a univariate empirical probability distribution for each yield scenario. The empirical distribution exactly follows the yield risk observed in history, so simulated values will be confined to their historical ranges. No trend was found in the historical yield data.

Price Data

Cotton futures price data were obtained from the former New York Board of Trade (now Intercontinental Exchange, or ICE) to specifically estimate November futures settlement prices for a December cotton contract and June for a July cotton contract (1997-2007). The November futures price was the expiring December futures contract price traded on the sixth trading day in November (1997-2006). This price was used to approximate the date of December option's expiration. Similarly price futures settlement data were collected for the first trading day in June for the expiring July contract. Spot price data for the first trading day in December and June for Lubbock, Texas as well as historical AWP data for the sixth trading day in November and first trading day in June were obtained from USDA-AMS data compiled at Texas A&M University (Gleaton 2007).

The November basis is the difference between November's spot price and the December contract futures price at the same day in November. The June basis is the difference between June's spot price and the July futures contract price on the same day.

The FAPRI January 2007 baseline forecast for national cotton price was 52 cents/lb. and for this study it was the deterministic national market price forecast. This national average annual farm price was is for the August 2007 to July 2008 marketing year. The historical average annual farm price data were obtained from FAPRI (2007).

The price data set was tested for trend. Ordinary least squares (OLS) regression method was used to determine the presence of time trend in historical price data (Hughes 1980). No statistically significant trend was found in either the price data or the basis for November and June based on the Student *t* test at the α equal to .05 level (Table 4).

Table 4. Summary of Trend Regression for Seven Price Variables

	National Price	June Spot	Nov Spot	Nov Basis	Basis June	June AWP	Nov AWP
Intercept	36.531	4030.102	4374.023	199.393	28.672	2722.837	2740.065
Slope	-0.018	-1.989	-2.159	-0.101	-0.016	-1.338	-1.347
R-Square	0.267	0.351	0.255	0.055	0.001	0.209	0.107
F-Ratio	3.280	4.864	3.083	0.519	0.010	2.377	1.083
Prob(F)	0.104	0.055	0.113	0.489	0.921	0.158	0.325
S.E.	0.010	0.902	1.230	0.141	0.160	0.868	1.294
T-Test	-1.811	-2.205	-1.756	-0.721	-0.102	-1.542	-1.041
Prob(T)	0.100	0.052	0.110	0.488	0.921	0.154	0.322

Based on a Student *t* test at a 95 percent confidence level, ten of the price variables were found to have statistically significant correlation indicating the need for multivariate simulation of price (Table 5). A MVEmp distribution was used to simulate the seven price variables to account for their correlation (Richardson *et al.* 2000). The empirical distribution was used due to the small number of observations. Since the data showed no historical trend, the price distribution was expressed as a percent deviation from mean for the seven price series (Table 5).

Table 5. Correlation Matrix and Statistical Test of the Correlation Coefficients for the Seven Price Variables

Correlation Matrix	National Price	June Spot	Nov Spot	Nov Basis	Basis June	June AWP	Nov AWP
National Price	1	0.85	0.95	0.16	0.11	0.81	0.93
June Spot		1	0.71	0.30	0.10	0.93	0.75
Nov Spot			1	0.10	0.14	0.63	0.92
Nov Basis				1	0.20	0.05	0.08
Basis June					1	0.09	0.19
June AWP						1	0.72
Nov AWP							1

Test Correlation Coefficients	June Spot	Nov Spot	Nov Basis	Basis June	June AWP	Nov AWP
National Price	0.86	0.48	0.21	0.01	0.97	0.56
June Spot		1.24	0.23	0.06	0.59	1.13
Nov Spot			0.40	0.08	1.42	0.61
Nov Basis				1.18	0.50	0.44
Basis June					0.07	0.22
June AWP						1.21
Confidence Level	99.7560%					
Critical Value	4.16					

Simulated Prices and Basis

National price is the main component in forecasting the other stochastic price variables. A two sample Student t and F tests were used to test if the simulated national price accurately reproduced its historical mean and variance (Table 6). The statistical test results fail to reject the hypotheses of no significant differences between the simulated national price mean and variance and the historical national price mean and variance at the 95 percent confidence level.

Table 6. Historical and Stochastic Distribution Comparison for National Price

Distribution Comparison of Simultated National Price & Historical National Price				
Confidence Level		95%		
	Test Value	Critical Value	P-Value	
2 Sample t Test	0.21	2.63	0.840	*Fail to Reject the Ho that the Means are Equal*
F Test	1.13	1.85	0.339	*Fail to Reject the Ho that the Variances are Equal*

These same distribution comparison tests were applied to the other six price variables. The tests showed that all simulated price variables statistically reproduced their historical distributions. Using a two sample Student *t* and *F* test, each test failed to reject the hypotheses that the simulated and historical distributions had no statistically significant differences between means and variances at a 95 percent confidence level (Table 7). The simulated price variables exhibited statistically the same correlation as was found in history at the 99 percent confidence level. A Student *t* test was used to statistically test each of the correlation coefficients and as indicated in Table 8, the test *t* statistic for each variable was less than the 4.16 critical value at the 99 percent level.

Table 7. Historical and Stochastic Distribution Comparison for Six Price Variables

Distribution Comparison of Simulated June 1st Spot & Historical June Spot

Confidence Level		95%		
	Test Value	Critical Value	P-Value	
2 Sample t Test	0.18	2.63	0.864	*Fail to Reject the Ho that the Means are Equal*
F Test	1.51	1.85	0.133	*Fail to Reject the Ho that the Variances are Equal*

Distribution Comparison of Simulated Nov Spot & Historical Nov Spot

Confidence Level		95%		
	Test Value	Critical Value	P-Value	
2 Sample t Test	-0.07	2.63	0.948	*Fail to Reject the Ho that the Means are Equal*
F Test	1.53	1.85	0.126	*Fail to Reject the Ho that the Variances are Equal*

Distribution Comparison of Simulated Basis Nov & Historical Nov Basis

Confidence Level		95%		
	Test Value	Critical Value	P-Value	
2 Sample t Test	0.19	2.63	0.856	*Fail to Reject the Ho that the Means are Equal*
F Test	1.46	2.55	0.261	*Fail to Reject the Ho that the Variances are Equal*

Distribution Comparison of Simulated Basis June & Historical Basis June

Confidence Level		95%		
	Test Value	Critical Value	P-Value	
2 Sample t Test	-0.02	2.63	0.988	*Fail to Reject the Ho that the Means are Equal*
F Test	1.13	1.85	0.335	*Fail to Reject the Ho that the Variances are Equal*

Distribution Comparison of Simulated June AWP & Historical June AWP

Confidence Level		95%		
	Test Value	Critical Value	P-Value	
2 Sample t Test	0.17	2.63	0.870	*Fail to Reject the Ho that the Means are Equal*
F Test	1.65	1.85	0.089	*Fail to Reject the Ho that the Variances are Equal*

Distribution Comparison of Simulated Nov AWP & Historical Nov AWP

Confidence Level		95%		
	Test Value	Critical Value	P-Value	
2 Sample t Test	0.26	2.63	0.801	*Fail to Reject the Ho that the Means are Equal*
F Test	1.52	1.85	0.130	*Fail to Reject the Ho that the Variances are Equal*

Table 8. Student t-Test between Historical and Simulated Price Correlation Coefficients

Correlation Matrix	National Price	June Spot	Nov Spot	Nov Basis	Basis June	June AWP	Nov AWP
National Price	1	0.85	0.95	0.16	0.11	0.81	0.93
June Spot		1	0.71	0.30	0.10	0.93	0.75
Nov Spot			1	0.10	0.14	0.63	0.92
Nov Basis				1	0.20	0.05	0.08
Basis June					1	0.09	0.19
June AWP						1	0.72
Nov AWP							1

Simulation/SERF

The Monte Carlo model was simulated for 500 iterations to estimate the empirical probability distributions of net cash income under three marketing strategies and six yield production assumptions. The net cash income probability density functions (PDF) were summarized with summary statistics and cumulative distribution function (CDF) charts and summary statistics and the ranked using SERF.

SERF was used because it has been shown to be a superior ranking method compared to stochastic dominance and is based on calculating certainty equivalents at all risk averse levels (Hardaker *et al.* 2004). CE's were calculated for annual income using the negative exponential utility function (Richardson 2007). The ARAC range for a negative exponential utility function is zero to four divided by wealth where four divided by wealth is representative of extreme risk aversion (Anderson and Dillion 1992). This ARAC range covers all rational DM's. The CE's are calculated at all ARAC's and presented as a chart. The scenario with the highest CE or the highest line in the SERF chart is preferred by all DM's who's ARAC is in the range.

Wealth used to calculate the ARAC was estimated from 2007 summary of assets for a representative Texas panhandle cotton producer provided by the Agricultural Food and Policy Center (AFPC). Assets not used for farming cotton were eliminated from the producer's assets to calculate wealth. The AFPC representative farm produced irrigated and dryland cotton. In determining the model's dryland farmers' wealth, irrigation related assets were eliminated from the AFPC representative farm's assets. The total assets for irrigated and for dryland were multiplied by the fraction of the farm's production devoted to each production method. Net worth was assumed to be 75 percent of total assets while liabilities were assumed to be the remaining 25 percent of the asset total. The farm grew 1000 acres of irrigated cotton and 367 acres of dryland cotton (Richardson 2007). Total assets per acre for the dryland representative farms are $722/acre, and the total assts per acre for the irrigated representative farm are $1176/acre. The upper ARAC's for dryland and irrigated were calculated as four divided by their respective per acre net worth.

CHAPTER V

RESULTS

This chapter is presented in four sections. Summary statistics of net cash income per acre, cumulative distribution function graphs (CDF), and stochastic efficiency with respect to a function graphs (SERF) are presented for six marketing strategies yield risk combinations. The final section incorporates a sensitivity analysis involving an increase in the mean national market price.

Summary Statistics

The summary statistics for net cash income per acre include mean, standard deviation, coefficient of variation, minimum, median, and maximum. The summary statistics of the net cash income per acre for the irrigated high yield variability scenario show the mean for the hedge marketing strategy is the highest at $91.97 (Table 9). The cash sale at harvest marketing strategy has a mean net cash income per acre of $38.86 followed by the cash sale in June marketing strategy at -$16.39. Cash sale in June marketing strategy had the lowest standard deviation of $172.67. Cash sale at harvest has a standard deviation of $187.99. The hedge marketing strategy had the highest standard deviation at $209.45. The hedge marketing strategy has the lowest absolute CV of 227.74. The lowest CV signifies a lower relative risk of net cash income. Each marketing strategy have a negative minimum net cash income (Table 9). The median net cash income, $123.67, for the hedge marketing strategy is higher than its respective mean. The medians $65.99 for cash sale at harvest and $0.24 for cash sale in June are both higher than each of their marketing strategies respective means (Table 9).

Table 9. Summary Statistics of Net Cash Income per Acre for Irrigated High Yield Risk Marketing Strategies

	Hedge	Cash Sale at Harvest	Cash Sale in June
Mean	91.97	38.86	-16.39
StDev	209.45	187.99	172.67
CV	227.74	483.82	-1053.57
Min	-511.38	-488.23	-503.16
Median	123.67	65.99	0.24
Max	530.56	364.93	253.48

In the summary statistics of net cash income for the irrigated medium yield variability scenario, the hedge strategy's net cash income mean is the highest at $78.46 followed by cash sale at harvest at $22.63 and then by cash sale in June at -$35.83 (Table 10). The hedge marketing strategy has the lowest absolute CV at 226.08 followed by the cash sale at harvest marketing strategy at 712.16. Each marketing strategy has a negative minimum net cash income.

Table 10. Summary Statistics of Net Cash Income per Acre for Irrigated Medium Yield Risk Marketing Strategies

	Hedge	Cash Sale at Harvest	Cash Sale in June
Mean	78.46	22.63	-35.83
StDev	177.38	161.13	146.06
CV	226.08	712.16	-407.68
Min	-311.99	-287.66	-326.91
Median	90.36	34.84	-20.65
Max	460.70	325.66	203.13

The summary statistics of net cash income for the irrigated low yield variability scenario indicate the mean for the hedge strategy is the highest at $311.47 followed by cash sale at harvest at $237.84 and followed by cash sale in June at $163.04 (Table 11).

This is the only simulated yield where each marketing strategy had positive means for net cash income per acre.

Table 11. Summary Statistics of Net Cash Income per Acre for Irrigated Low Yield Risk Marketing Strategies

	Hedge	Cash Sale at Harvest	Cash Sale in June
Mean	311.47	237.84	163.04
StDev	182.25	153.22	138.08
CV	58.51	64.42	84.69
Min	-255.24	-223.16	-269.17
Median	324.69	242.80	170.91
Max	762.80	551.82	402.75

The summary statistics of net cash income for the dryland high yield variability scenario are presented in Table 12. The simulated mean for the hedge marketing strategy is the highest at -$87.21 followed by cash sale at harvest at -$96.27 and by cash sale in June at -$109.76. The maximum net cash income is positive only for the hedge strategy. These net cash incomes generated by the model do not incorporate crop insurance which would supply a floor for net cash income.

Table 12. Summary Statistics of Net Cash Income per Acre for Dryland High Yield Risk Marketing Strategies

	Hedge	Cash Sale at Harvest	Cash Sale in June
Mean	-87.21	-96.27	-109.76
StDev	67.57	65.08	59.62
CV	-77.47	-67.61	-54.31
Min	-208.11	-204.16	-210.18
Median	-80.69	-91.77	-104.75
Max	18.60	-13.72	-30.79

Note: Dryland

The summary statistics of net cash income for the dryland medium yield variability scenario display the mean for the hedge strategy as the highest at -$82.38 followed by cash sale at harvest at -$91.88 and followed by cash sale in June at -$105.77

(Table 12). The summary statistics of net cash income for the dryland low yield variability scenario indicates the mean for the hedge strategy is the highest at -$44.48 followed by cash sale at harvest at -$56.91 and then by cash sale in June at -$74.34 (Table 14). The minimum net cash incomes for each dryland yield scenario are nearly the same (Table 12, Table 13, and Table 14) due to the dryland farms having a 10 to 20 percent probability of zero cotton production found for each historic dryland yield scenario. High yield risk farms earn lower minimum, mean, and maximum net cash incomes across the cash sale at harvest and the cash sale in June marketing strategies compared to farms with less yield risk.

Table 13. Summary Statistics of Net Cash Income per Acre for Dryland Medium Yield Risk Marketing Strategies

	Hedge	Cash Sale at Harvest	Cash Sale in June
Mean	-82.38	-91.88	-105.77
StDev	75.73	73.10	66.96
CV	-91.92	-79.56	-63.31
Min	-208.30	-204.16	-210.18
Median	-90.27	-94.40	-109.37
Max	113.34	103.10	56.75

Table 14. Summary Statistics of Net Cash Income per Acre for Dryland Low Yield Risk Marketing Strategies

	Hedge	Cash Sale at Harvest	Cash Sale in June
Mean	-44.48	-56.91	-74.34
StDev	90.03	86.96	78.90
CV	-202.39	-152.81	-106.13
Min	-210.66	-205.24	-211.25
Median	-53.80	-70.35	-86.05
Max	164.92	144.84	93.23

CDF Graphs of Net Cash Income

The net cash income CDF graphs were developed using simulated net cash income values for the six yield risk/marketing strategies. The graphs illustrate probabilities of drawing a net cash income less than a specified value. The horizontal axis represents net cash income (where zero is a $0 net cash income per acre) while the vertical axis represents probabilities. Each CDF line represents a different marketing strategy (Figure 2).

The CDF graph of net cash income for the high yield variability scenario shows the hedge marketing strategy has the highest probability, 72 percent, of having a positive net cash income (Figure 2). That is, the black line crosses the vertical breakeven line at the 28 percent cumulative probability level. The cash sale at harvest marketing strategy has roughly a 68 percent probability of having a positive net cash income. The cash sale in June marketing strategy has a 50 percent probability of having a positive net cash income. Because the CDF's cross, one can not easily rank the marketing alternatives.

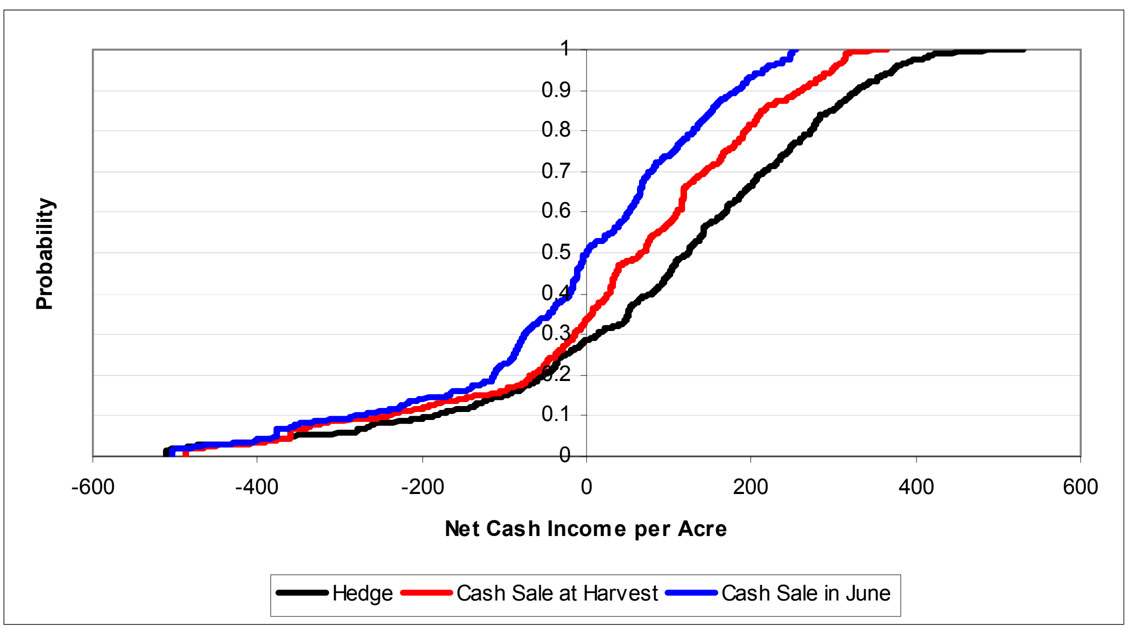

Figure 2. Cumulative Distribution Function Graph of Net Cash Income for the Irrigated High Yield Variability Scenario

Figure 3 is the CDF graph of net cash income for the irrigated medium yield variability scenario. The hedge marketing strategy has nearly a 69 percent probability of having a positive net cash income. The hedge marketing strategy also shows significantly higher positive tail for net cash income compared to the other marketing strategies. The cash sale at harvest marketing strategy has roughly a 64 percent probability of having a positive net cash income. The cash sale in June marketing strategy has a 45 percent probability of having a positive net cash income.

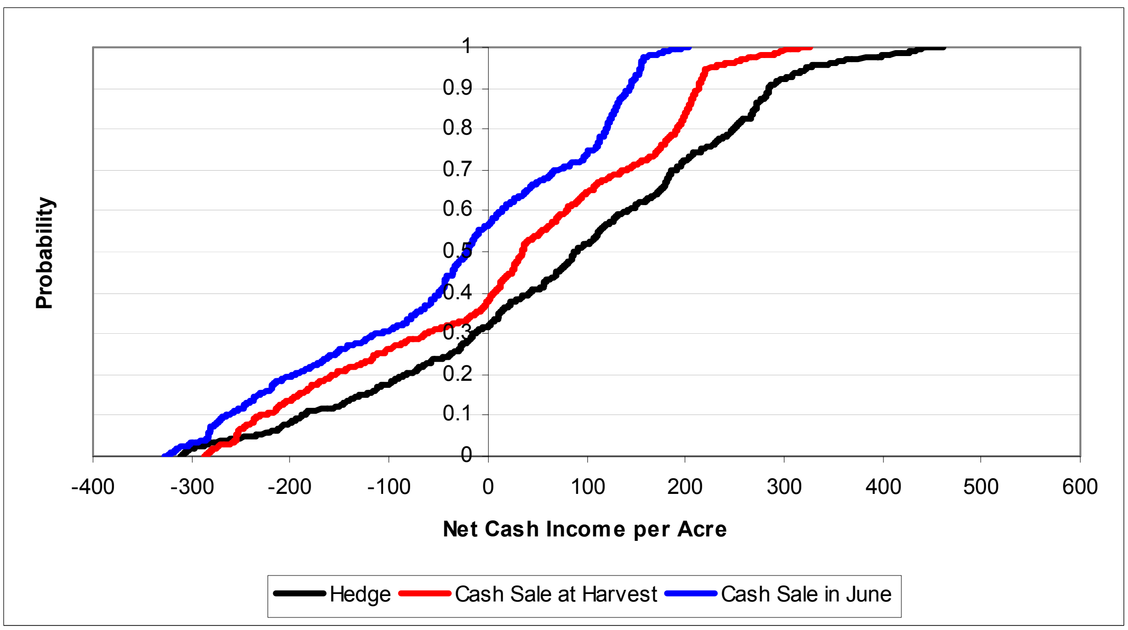

Figure 3. Cumulative Distribution Function Graph of Net Cash Income for the Irrigated Medium Yield Variability Scenario

The CDF graph of net cash income for the representative low yield variability scenario indicates the hedge marketing strategy has a 93 percent probability of having a positive net cash income (Figure 4). The hedge and cash sale at harvest marketing strategies have a 75 percent probability of earning $200 per acre or higher net cash income. All of the marketing strategies have significantly higher probability of a positive net cash income under the low yield risk scenario than the other irrigated and dryland yield variability scenarios.

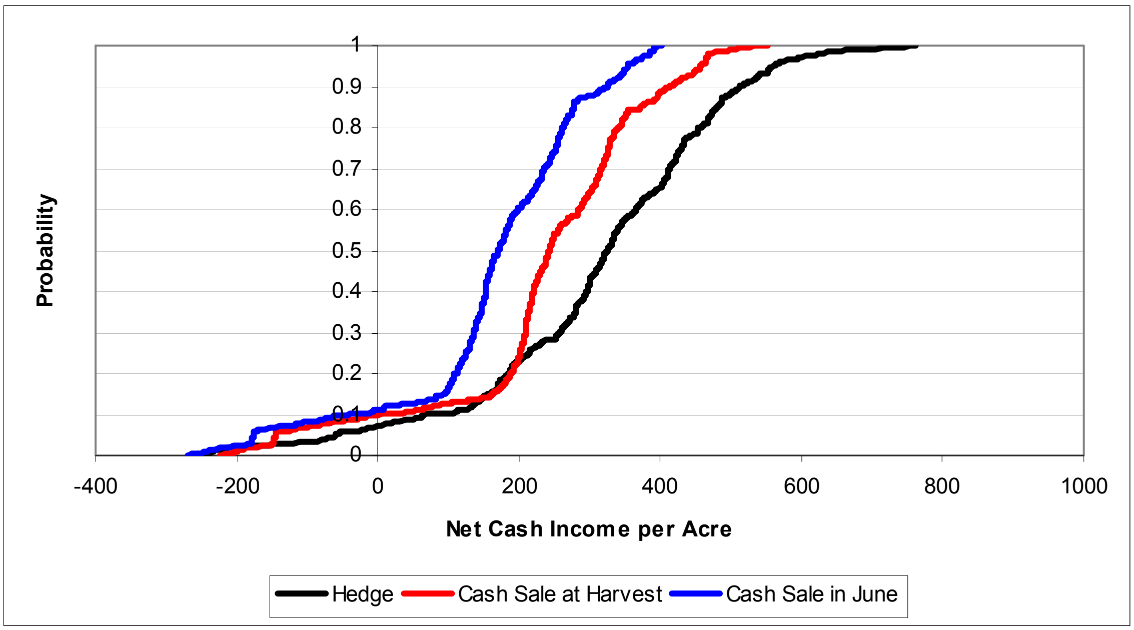

Figure 4. Cumulative Distribution Function Graph of Net Cash Income for the Irrigated Low Yield Variability Scenario

The CDF graph of net cash income for the representative dryland farm with high yield variability indicates the hedge marketing strategy has only a five percent probability of having a positive net cash income (Figure 5). It is the only marketing strategy with a probability of producing a positive net cash income. The higher risk associated with dryland production results in negative projected net cash incomes given the specified cost structure and no crop insurance (Figure 5).

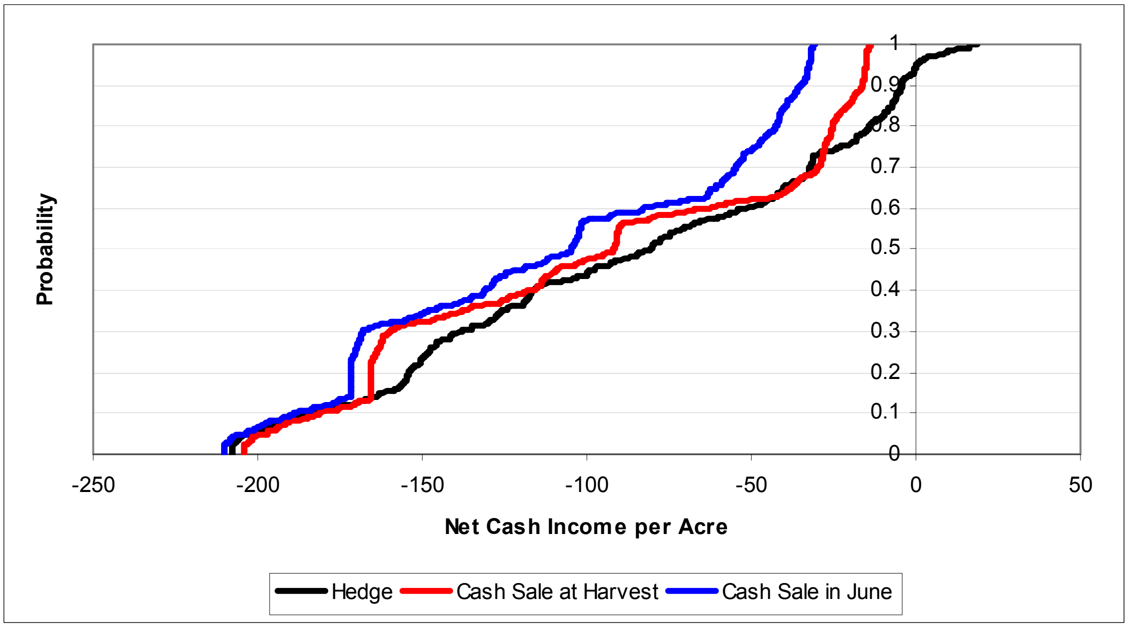

Figure 5. Cumulative Distribution Function Graph of Net Cash Income for the Dryland High Yield Variability Scenario

The CDF graph of net cash income for the representative dryland farm with medium yield variability scenario shows the hedge has the highest probability of a positive net cash income of 14 percent (Figure 6). The cash sale at harvest strategy has a 13 percent probability of producing positive net cash income. The cash sale in June marketing strategy has a 10 percent probability of a positive net cash income.

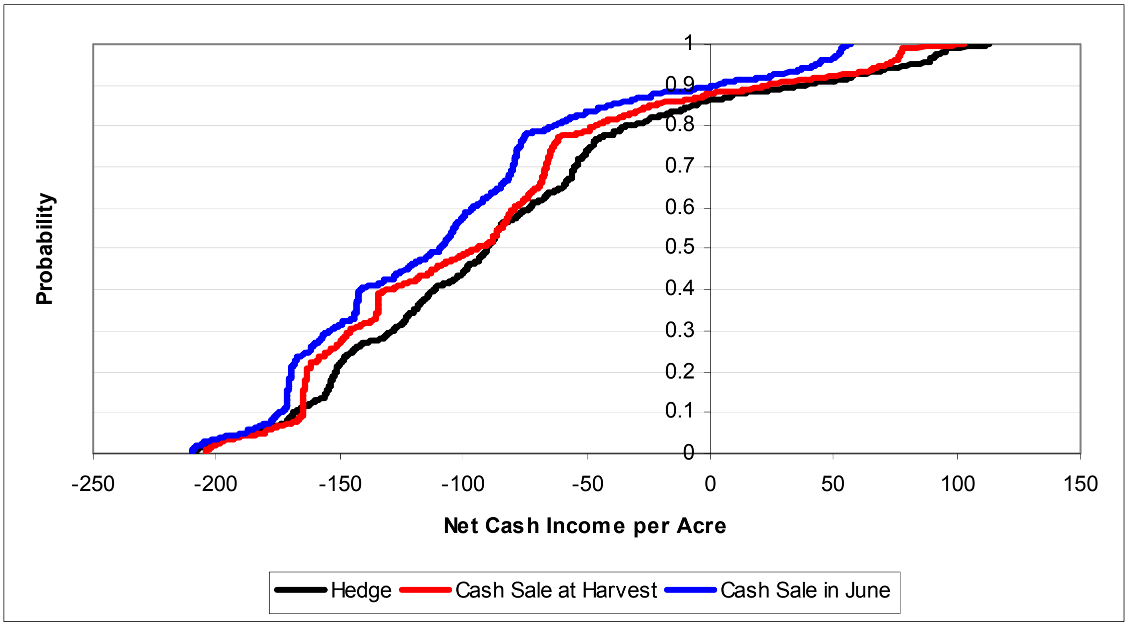

Figure 6. Cumulative Distribution Function Graph of Net Cash Income for the Dryland Medium Yield Variability Scenario

The CDF graph of net cash income for the representative low yield variability dryland farm scenario indicates the hedge marketing strategy has a 34 percent probability of a positive net cash income (Figure 7). The cash sale at harvest marketing strategy has 30 percent probability of producing positive net cash income. The cash sale in June marketing strategy has a 15 percent probability of obtaining positive net cash income. Each marketing strategy for this representative farm has a higher probability of obtaining positive net cash income compared to the other dryland yield variability scenarios.

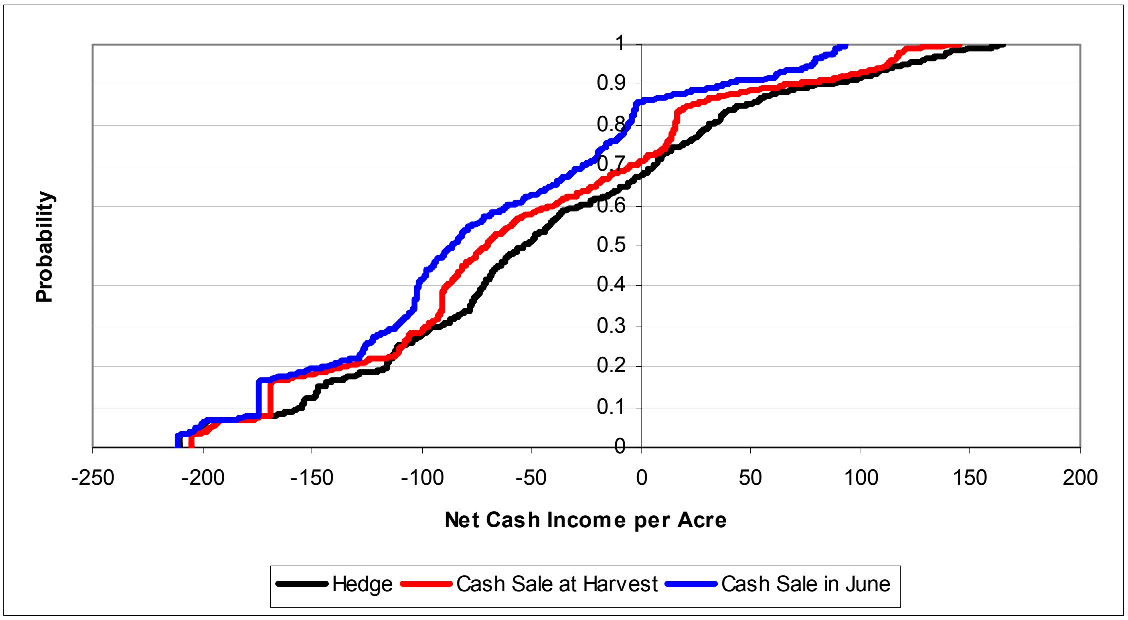

Figure 7. Cumulative Distribution Function Graph of Net Cash Income for the Dryland Low Yield Variability Scenario

The hedge marketing strategy has the highest probability of positive net cash income for every irrigated yield variability scenario but it also has a chance of lower net cash incomes compared to cash sale at harvest. The lower net cash income is due to the cost of the premium associated with buying a put option. Each strategy generally has parallel CDF's for the three marketing strategies. Though net cash income CDF's lines touched and crossed at some points, the probability of higher net cash incomes could be summarized as: the hedge, then the cash sale at harvest, followed by the cash sale in June. However, when the lines on the CDF cross or touch, the probability of drawing a specific net cash income is the same for the marketing strategies, thus not allowing a DM to rank the strategies by first order stochastic dominance. To identify the preferred marketing strategy for each yield variability level, SERF analysis was used.

Ranking Marketing Strategies

The three marketing strategies were ranked using SERF for each of the irrigated and dryland representative west Texas yield variability scenarios in this section. The black line in each chart represents the hedge marketing strategy, the red line represents the cash sale at harvest marketing strategy, and the blue line represents the cash sale in June marketing strategy. The vertical axis represents CE in dollars and the horizontal axis represents ARAC levels.

The SERF analysis ranks the hedge strategy as the most preferred strategy with a positive CE value of $92 per acre across all risk averse DM's (Figure 8). The cash sale at harvest marketing strategy is the second most preferred marketing strategy by all risk averse DM's with a CE value of about $39 per acre. Cash sale in June is the least preferred strategy with a CE value of -$18 per acre. Negative CE indicates that the DM is better off not farming cotton if the cash sale in June is his/her only marketing strategy. The hedge marketing strategy outperforms the cash sale at harvest by nearly $53 per acre and cash sale in June by nearly $110 per acre.

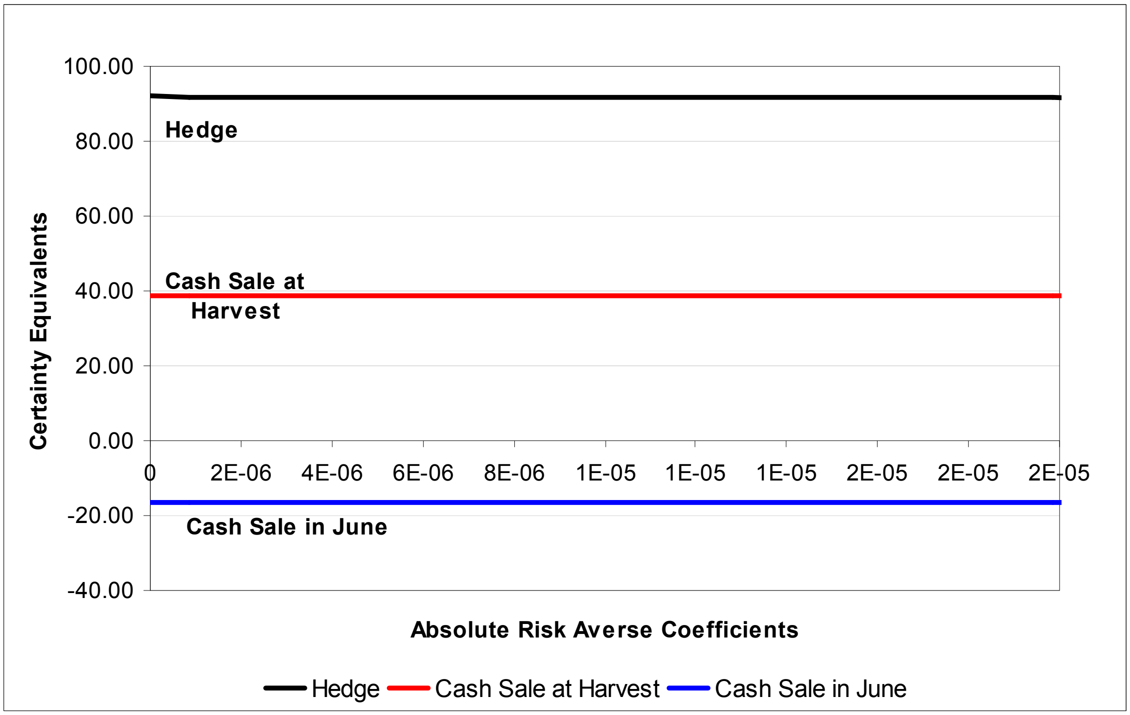

Figure 8. SERF Ranking of Marketing Strategies for the Representative Irrigated High Yield Variability Scenario

Given the SERF analysis for the irrigated medium yield variability scenario, the hedge marketing strategy is most preferred with a CE value of nearly $80 per acre for all risk averse DM's (Figure 9). The cash sale at harvest marketing strategy is the second most preferred strategy with a CE estimated at about $23 per acre. The cash sale in June marketing strategy is the least preferred strategy with a CE of about -$37 per acre. The hedge marketing strategy outperforms cash sale at harvest and cash sale in June by $57 and $117 per acre, respectively.

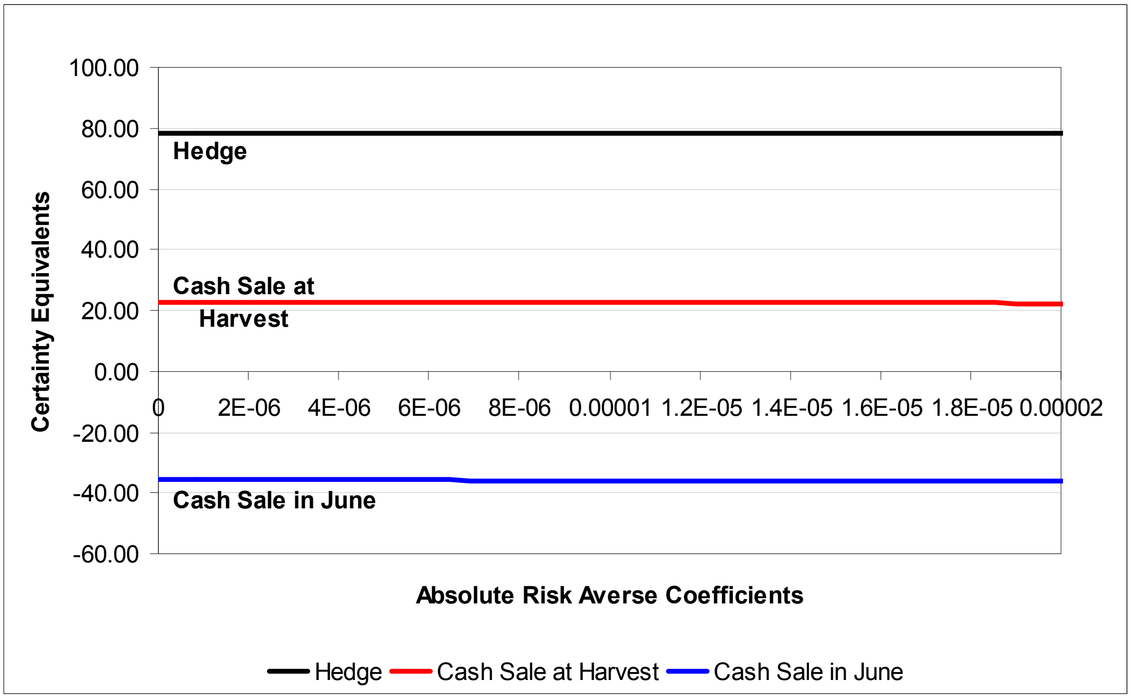

Figure 9. SERF Ranking of Marketing Strategies for the Representative Irrigated Medium Yield Variability Scenario

The SERF analysis for the irrigated low yield variability scenario indicates that all three of the marketing strategies have positive CE values (Figure 10). The hedge marketing strategy is preferred with a CE estimated at $310 per acre. The cash sale at harvest is the second most preferred marketing strategy with a CE estimated at $245 per acre. The cash sale in June marketing strategy is the least preferred marketing strategy with a CE of $160 per acre. The hedge marketing strategy outperforms cash sale at harvest by an estimated $65 and cash sale in June by an estimated $150 per acre.

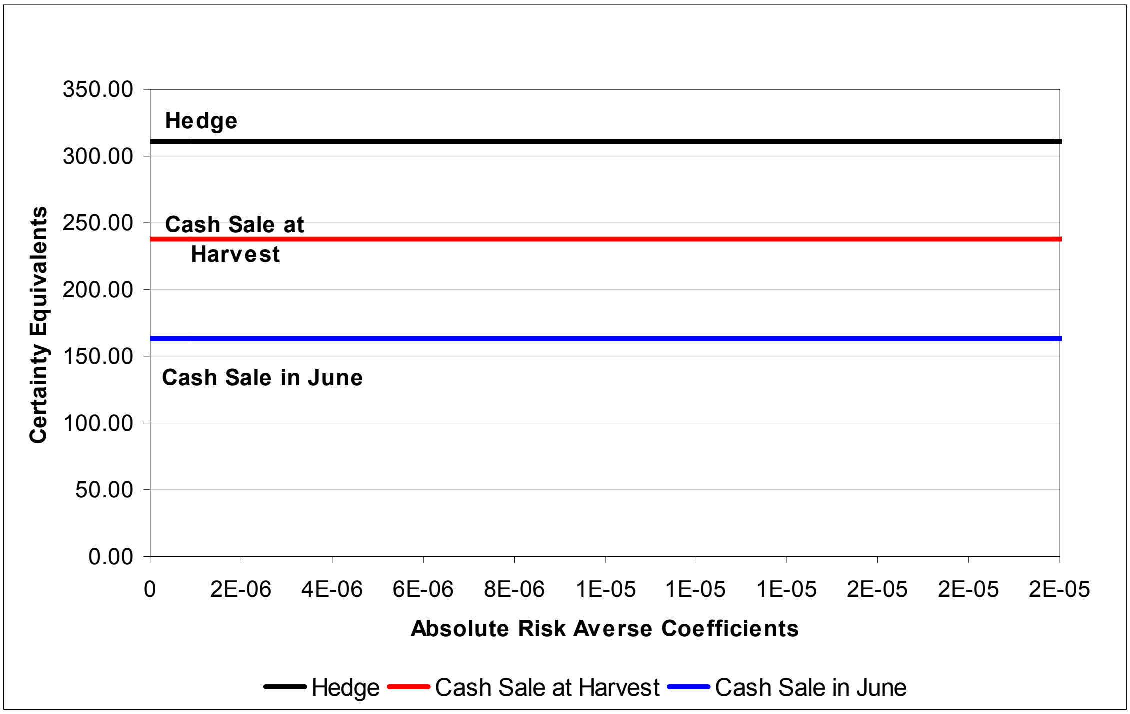

Figure 10. SERF Ranking of Marketing Strategies for the Representative Irrigated Low Yield Variability Scenario

Under the high yield risk dryland farming scenario, the hedge marketing strategy was the most preferred, followed by cash sale at harvest, and then by cash sale in June (Figure 11). The negative CE values indicate that the DM is better off not farming dryland cotton if these are his/her only marketing strategies (Figure 11). The negative CE values are a result of the low yields and high risk observed for the representative farm's historical yields for dryland cotton.

Figure 11. SERF Ranking of Marketing Strategies for the Representative Dryland High Yield Variability Scenario

The SERF analysis for the dryland medium yield variability scenario summarized the CE values for this yield risk variability as being marginally better than the high yield risk variability (Figure 11 and 12). The hedge marketing strategy has the highest CE value estimated at -$82 per acre (Figure 12). Cash sale at harvest is the second most preferred strategy with a CE value of about -$91 per acre. The cash sale in June marketing strategy is the least preferred strategy with a net cash income of -$107 per acre. Again, the DM's utility is higher for not farming dryland cotton at this yield variability using these marketing strategies without crop insurance.

Figure 12. SERF Ranking of Marketing Strategies for the Representative Dryland Medium Yield Variability Scenario

The SERF analysis of the three marketing strategies for the dryland low yield variability scenario is summarized in Figure 13. All of the marketing strategies have higher CE values than the other dryland yield variability scenarios (Figures 11-13). The highest ranked hedge marketing strategy has a CE value of -$45 per acre. The second most preferred marketing strategy, cash sale at harvest, also had a CE value of -$57 per acre. The cash sale in June marketing strategy is the least preferred strategy with a CE value of -$75 per acre. All of the dryland variability scenarios have negative CE values.

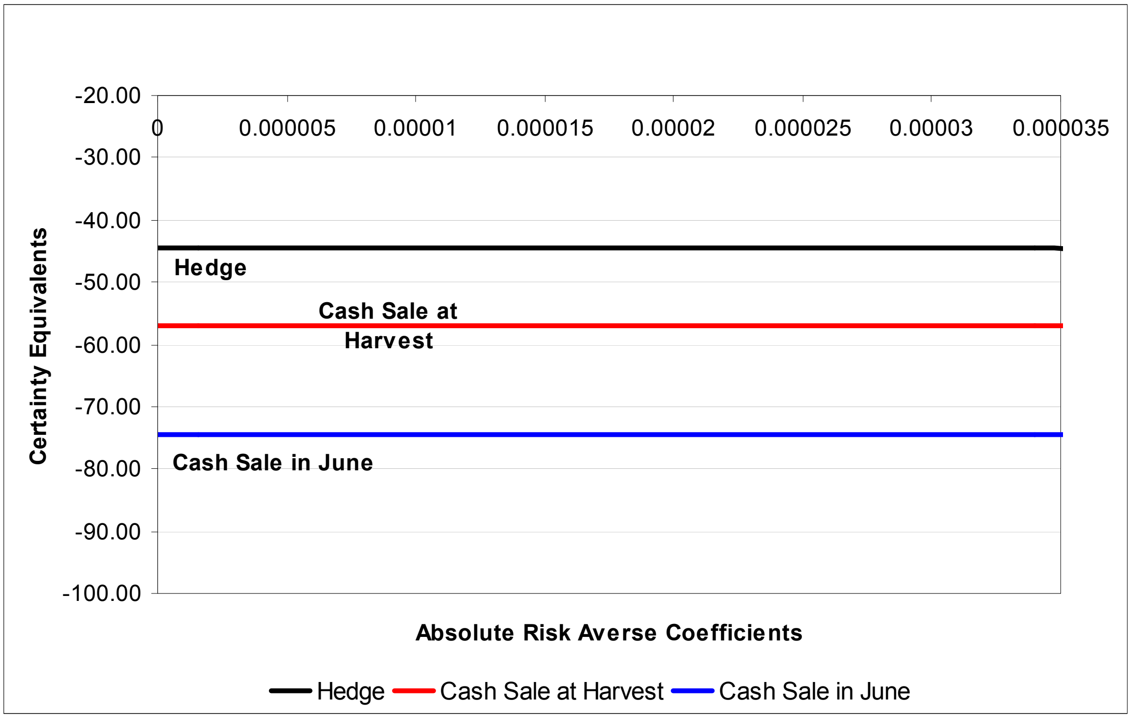

Figure 13. SERF Ranking of Marketing Strategies for the Representative Dryland Low Yield Variability Scenario

SERF analysis indicates that for each irrigated and dryland representative yield variability scenario, the hedge (purchase of a put option) is preferred, followed by cash sale at harvest, and then cash sale in June marketing strategy for all risk averse DM's. The representative irrigated yield variability scenarios see a positive CE for the hedge and cash sale at harvest marketing strategies using a negative exponential utility function. While the cash sale in June marketing strategy only has a positive CE with irrigated low yield variability.

Sensitivity Analysis

The 2008 December cotton futures price is forecasted to average higher throughout 2007-2008 compared to 2007 December cotton futures price (Robinson 2008). A sensitivity analysis of the SERF rankings to a significant change in price was calculated based on a 75 cent/lb. national market price. The new SERF analysis used the net cash income probability distribution generated with only an increase of mean cotton price to 75 cents/lb.

With a 75 cents/lb. mean price, what would be expected to happen to the ranking of the marketing strategies in the model? The intrinsic value for the put option strategy should decline as price rises above the 65 cents/lb. strike price for the put option. The cash receipts for yield should increase for all the marketing strategies. Government payments should be reduced as the deterministic forecast for national price is above the target price of 72.4 cents/lb. which is crucial to the calculation of CCP.

Summary statistics of the forecasted LDP and CCP for the sensitivity analysis using a 75 cent/lb. national market price saw a 52 percent increase for irrigated and a 46 percent increase in the probability of not receiving an LDP as compared to the analysis using a 52 cent/lb. national price (Table 15). The mean for the LDP payment dropped by $59.77 for irrigated and $10.59 for dryland. The probability of receiving no CCP payment increased by 63 percentage points for irrigated and dryland. The mean CCP is also significantly lower: $70.87 for irrigated and $21.59 for dryland (Table 15). As expected, the direct payment stayed the same for irrigated and dryland. The higher national price raised mean cash market receipts for the sale of cotton on the spot market in November by $195.72 per acre for irrigated and $36.28 per acre for dryland (Table 15). The same reduction in government payments and increases in cash receipts was seen for the hedge marketing strategy and similar statistics are comparable to the cash sale in June marketing strategy.

Table 15. Summary Statistics of Government Payments and Cash Sale Market Receipts for High Yield Variability Scenario

	Irrigated		Dryland	
	Farm Price $.52	Farm Price $.75	Farm Price $.52	Farm Price $.75
LDP Payment				
Mean	69.20	9.43	12.46	1.52
StDev	75.84	31.98	17.30	6.27
Min	0.00	0.00	0.00	0.00
Max	362.00	187.74	81.17	42.10
Prob. of Zero	37%	89%	44%	90%
CCP Payment				
Mean	87.84	16.97	26.76	5.17
StDev	53.00	39.34	16.14	11.98
Min	0.00	0.00	0.00	0.00
Max	127.21	127.21	38.75	38.75
Prob. of Zero	14%	77%	14%	77%
Direct Payment				
Mean	36.11	36.11	18.82	18.82
StDev	0.00	0.00	0.00	0.00
Min	36.11	36.11	18.82	18.82
Max	36.11	36.11	18.82	18.82
Prob. of Zero	0%	0%	0%	0%
Cash Sale Market Reciepts				
Mean	397.27	592.99	73.69	109.97
StDev	193.75	286.17	61.93	91.99
Min	0.00	0.00	0.00	0.00
Max	897.08	1324.46	200.24	295.61
Prob. of Zero	5%	5%	15%	15%

The SERF analysis for the representative irrigated high yield variability scenario ranks cash sale at harvest as the most preferred marketing strategy with a CE of $105 per acre (Figure 14). The hedge marketing strategy is the second most preferred risky alternative for all risk averse DM's with a CE at $90 per acre. The cash sale in June marketing strategy is the least preferred risky alternative with a CE of $5 per acre. The hedge marketing strategy is now ranked lower in preference by a DM because the lack of intrinsic value for the put option. The stochastic national price and November basis define the November futures price for a December contract. As a result, the model calculated the probability of a futures price above the exogenous strike price of 65 cents/lb., thus eliminating the intrinsic value. The difference in CE values between the cash sale at harvest and hedge marketing strategies equals the premium for the amount of the crop hedged. The two other irrigated yield variability scenarios using the 75 cents/lb. national market price have the same ranking of preference as this scenario. All of the marketing strategies in each yield variability scenario have positive CE's.

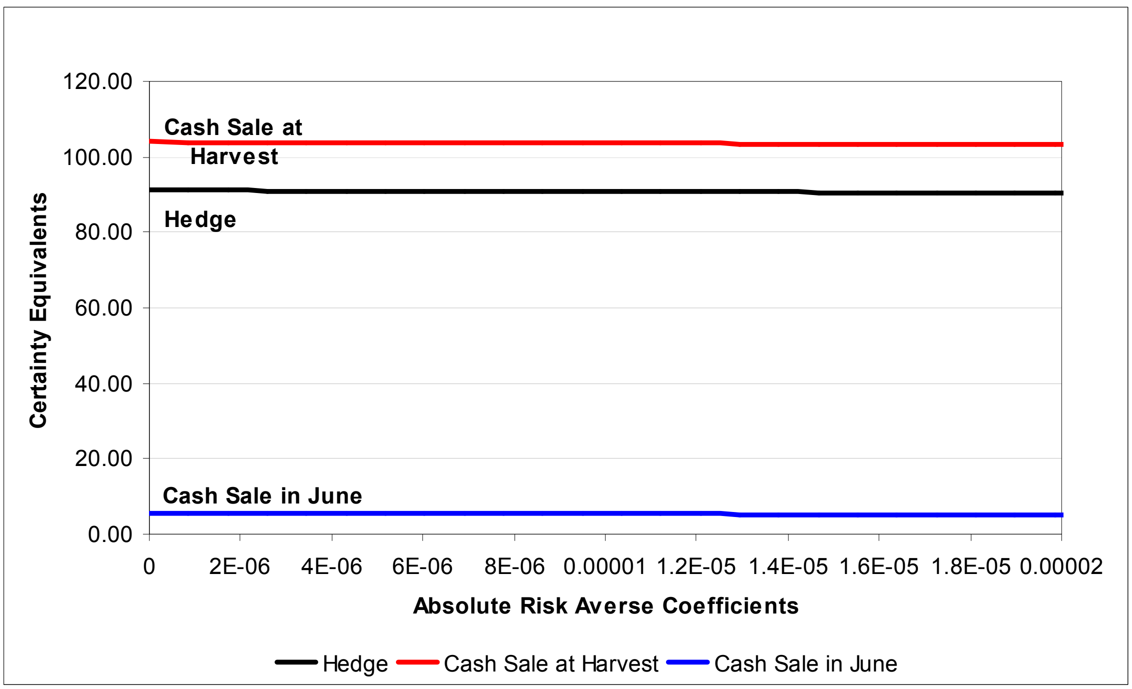

Figure 14. SERF Ranking of Marketing Strategies for the Representative Irrigated High Yield Variability Scenario with Increase of Mean Cotton Price

The SERF analysis for the dryland high yield variability is summarized in Figure 15. Cash sale at harvest marketing strategy has a CE of -$93 per acre. The hedge is the second preferred marketing strategy by a DM with a CE of roughly -$95 per acre. The cash sale in June marketing strategy is the least preferred strategy with a CE value of about -$113 per acre. All of the dryland yield variability scenarios have negative CE values and the same ranking of the market strategies.

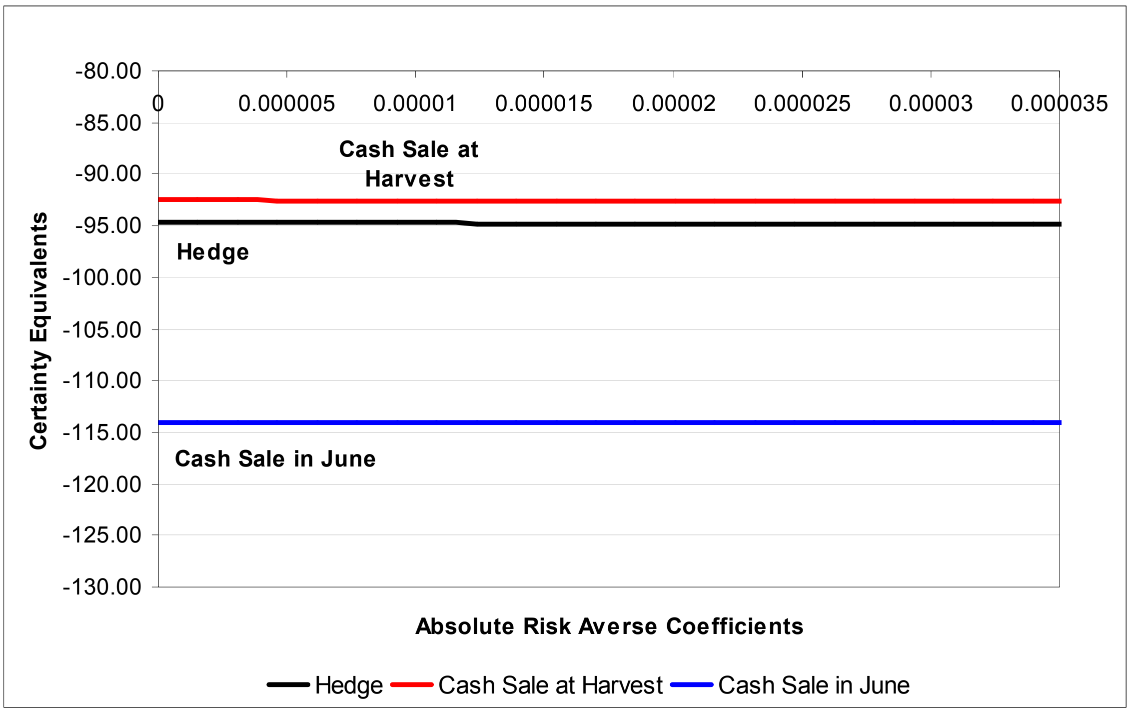

Figure 15. SERF Ranking of Marketing Strategies for the Representative Dryland High Yield Variability Scenario with Increase of Mean Cotton Price

SERF analyses for the higher national market price ranks the cash sale at harvest marketing strategy over the hedge and cash sale in June marketing strategies for each yield variability scenario. The irrigated yield variability scenarios see an increase in CE values for each marketing strategy as compared to 52 cents/lb. analysis. However, the representative dryland yield variability scenarios see a decrease in CE value for the hedge and cash sale in June marketing strategies in the high and medium yield variability scenarios. The decrease in CE values for these yield variability scenarios is explained by the decreased government payments (Table 15).

The irrigated yield variability scenarios have higher CE's for the sensitivity analyses using a 75 cents/lb. national market price (Table 16). For each marketing strategy at each irrigated yield variability scenario, CE's for the sensitivity analysis are consistently higher than the irrigated yield variability scenarios using a 52 cents/lb. national market price (Table 16).

Table 16. Certainty Equivalent Value Comparison for Irrigated Yield Variability Scenarios

Irrigated Yield Variability Scenarios CE Values for Marketing Strategies with $.52 Mean Cotton Price

	High Yield Variabilty CE's	Medium Yield Variability CE's	Low Yield Variability CE's
Hedge Marketing	$92	$80	$310
Cash Sale at Harvest	$39	$23	$245
Cash Sale in June	-$18	-$37	$160

Irrigated Yield Variability Scenarios CE Values for Marketing Strategies with $.75 Mean Cotton Price

	High Yield Variabilty CE's	Medium Yield Variability CE's	Low Yield Variability CE's
Hedge Marketing	$90	$120	$355
Cash Sale at Harvest	$105	$137	$375
Cash Sale in June	$5	$30	$245

The sensitivity analysis showed an increased net cash income risk for dryland farmers with high relative yield risk variability due to losing their LDP and CCP government payments (Table 17). As a result the hedge and cash sale in June marketing strategies for the dryland high and medium yield variability scenarios have lower CE values for the 75 cents/lb. mean price as compared to the 52 cents/lb. mean price.

Table 17. Certainty Equivalent Value Comparison for Dryland Yield Variability Scenarios

Dryland Yield Variability Scenarios CE Values for Marketing Strategies with $.52 Mean Cotton Price			
	High Yield Variabilty CE's	Medium Yield Variability CE's	Low Yield Variability CE's
Hedge Marketing	-$88	-$82	-$45
Cash Sale at Harvest	-$96	-$91	-$57
Cash Sale in June	-$110	-$107	-$75

Dryland Yield Variability Scenarios CE Values for Marketing Strategies with $.75 Mean Cotton Price			
	High Yield Variabilty CE's	Medium Yield Variability CE's	Low Yield Variability CE's
Hedge Marketing	-$95	-$90	-$41
Cash Sale at Harvest	-$93	-$88	-$39
Cash Sale in June	-$113	-$109	-$68

Summary

Using the FAPRI 2007 national price baseline of 52 cents/lb., the SERF analyses ranked the hedge marketing strategy as being most preferred by all risk averse DM's across all yield variability scenarios. The cash sale at harvest was ranked second, followed by the cash sale in June marketing strategy.

Buying a put option earlier in the year, if the strike price for that option is below futures price, provides an 'out of the money' option. This option can now become cheap insurance, depending on the premium, against downside price risk. The hedge marketing strategy ranking suggests that when a producer has an opportunity to buy a put option contract at a strike price of 65 cents/lb. with a premium of 3 cents/lb., they will increase utility relative to the other marketing strategies.

The sensitivity analyses increased the FAPRI 2007 national price baseline by 45 percent to 75 cents/lb. The SERF analyses rankings changed with the higher forecasted national market price. The SERF analysis shows that cash sale at harvest is the most preferred strategy for all risk averse DM's in each production method and yield risk variability scenario. The hedge and then cash sale in June marketing strategies consistently follow the cash sale at harvest in preference by all risk averse DM's.

CHAPTER VI

SUMMARY AND CONCLUSIONS

The objective of the study was to identify risk efficient marketing strategies for a utility maximizing cotton farmer in the west Texas High Plains. To accomplish this, the study used stochastic efficiency with respect to a function (SERF) to systematically rank risky alternative marketing strategies. A Monte-Carlo simulation model was used to estimate the probability distributions of net cash income for alternative marketing strategies: 1) forward pricing with put options, 2) selling the crop at harvest using spot price cash sale, 3) cash sale in June after harvest.

Historical data of cotton national market price, futures settlement prices, Lubbock spot price, and adjusted world price were used in a Monte Carlo budget simulation model. Simulated prices were used with parameters for the three marketing strategies to estimate the probability distributions of net cash income per acre. Three levels of yield risk were assumed for both dryland and irrigated production budgets. SERF was used to determine the rankings of marketing strategies for each yield variability scenario, for risk averse decision makers (DM).

Results

The model simulated two different forecasts for national market price. The first analysis used the 2007 Food and Agriculture Policy Research Institute (FAPRI) national market price forecast for cotton of 52 cents/lb. The second analysis used a national market price for cotton of 75 cents/lb. The analyses found different results as to the ranking of the marketing strategies for utility-maximizing, risk averse DM's.

The same marketing strategy was dominate for both irrigated and dryland production methods under the 52 cents/lb. national market price. SERF analysis identified a hedge as being the most preferred marketing strategy for all risk averse DM's across three yield risk scenarios. Cash sale at harvest and cash sale in June were ranked second and third, respectively.

Assuming a higher mean national market price (75 cents/lb.), the most preferred marketing strategy for all risk averse DM's was cash sale at harvest for both dryland and irrigated production systems at three yield risk scenarios. The hedge and then cash sale in June marketing strategies consistently ranked second and third, respectively.

Limitations

A limitation of this approach is the assumption that future price and yield risk is reflected by historical distributions of price variables. Contemporary speculative movements are increasingly influencing the markets, thus prices may be more volatile in the future.

Further Study

The model can be expanded for more marketing strategies. Marketing strategies that could be included and compared are various spreads and using a naïve strategy by selling a percentage of the crop over the marketing year. Such marketing strategies have not yet been comprehensively compared in cotton which has shown the potential for seasonality versus other storable commodities. Different levels of crop insurance can be included with the analysis of the marketing strategies.

REFERENCES

Anderson, J.R., and J.L. Dillion. *Risk Analysis in Dryland Farming Systems.* Rome, FAO Farming Systems Management Series No. 2, 1992.

Bailey, D., and J.W. Richardson. "Analysis of Selected Marketing Strategies: A Whole-Farm Simulation Approach." *American Journal of Agricultural Economics* 67(November 1985):813-820.

Barham, E.H., *Mitigating Cotton Revenue Risk through Irrigation, Insurance, and/or Hedging*. M.S. thesis, Texas A&M University, College Station, August 2007.

Brorsen, W., D. Bailey and J.W. Richardson. "Investigation of Price Discovery and Efficiency for Cash and Futures Cotton Prices." *Western Journal of Agricultural Economics* 9(July 1984):170-176.

Carter, C. A. *Futures and Options Markets: An Introduction.* Long Grove, IL. Waveland Press, Inc., 2003.

Chavez, M. J., J. R.C. Robinson, and V. Salin. "Normal Backwardation and the U.S. Cotton Futures Market: 1986 – 2006." Paper presented at the 2007 Proceedings of the Beltwide Cotton Conferences, Nonwovens Symposium, New Orleans, January 9-12, 2007.

Coble, K.H., M. Zuniga, R. Heifner. "Evaluation of the Interactions of Risk Management Tools for Cotton and Soybeans." *Agricultural Systems* 75(March 2003):323-340.

Curtis, C.E., A. Hummel, and O. Isengildina-Massa. "Is There a "Right" Time to Buy Options Pre-harvest?" Paper presented at the 2007 Proceedings of the Beltwide Cotton Conferences, Nonwovens Symposium, New Orleans, January 9-12, 2007.

FAPRI, Food and Agricultural Policy Research Institute- FAPRI 2007 U.S. and World Agricultural Outlook Database. Internet Site: http://www.fapri.org/tools/outlook.aspx (Accessed October 17, 2007).

Gleaton, C. S. Personal Communication. Texas A&M University, Department of Agricultural Economics, October 2007.

Hardaker, J., J. W. Richardson, G. Lien, and K. Schumann, "Stochastic Efficiency Analysis with Risk Aversion Bounds: A Simplified Approach." *The Australian Journal of Agricultural and Resource Economic* 48(June 2004):253-270.

Kidwell, D.S., D.W. Blackwell, D.A. Whidbee, R. L. Peterson. *Financial Institutions, Markets, and Money:* 9th Edition. Hoboken, NJ. John Wiley & Sons, Inc., 2006.

Klose, S. L. Personal Communication. Texas A&M University Department of Agricultural Economics, October 2007.

Kolb, R.W. "Is Normal Backwardation Normal?" *Journal of Futures Markets* 12(February 1992):75-91.

Lien, G., S. Størdal, J.B. Hardaker, L.J. Asheim. "Risk Aversion and Optimal Forest Replanting: A Stochastic Efficiency Study." *European Journal of Operational Research* 181(September 2007):1584-1592.

McCarl, B.A. "Preference among Risky Prospects under Constant Risk Aversion." *Southern Journal of Agricultural Economics* 20(1988):25-55.

Meyer, J. "Choice among Distributions." *Journal of Economic Theory* 14(1977):326-336.

Monke, J. 2004. "Farm Commodity Programs: Direct Payments, Counter-Cyclical Payments, and Marketing Loans." Washington DC: CRS Report for Congress. Resources, Science, and Industry Division. Library of Congress, Order Code RS21779 (2004).

Richardson, J.W. Personal Communication. Texas A&M University Department of Agricultural Economics, October 2007.

Richardson, J.W., B. Herbst, A. Duncan, M. Besten, P. van Hoven. "Location Preference for Risk-Averse Dutch Dairy Farmers Immigrating to the United States." *Journal of Agricultural and Applied Economics* 39,3(December 2007):735-748.

Richardson, J. W., S.L. Klose, and A.W. Gray. "An Applied Procedure for Estimating and Simulating Multivariate Empirical (MVE) Probability Distributions in Farm-Level Risk Assessment and Policy Analysis." *Journal of Agricultural and Applied Economics* 32,2(August 2000): 299-315.

Richardson, J.W. *Simulation for Applied Risk Management.* Texas A&M University. College Station, TX: Simetar, Inc., 2007.

Richardson J. W. and J. L. Outlaw. "Ranking Risky Alternatives: Innovations in Subjective Utility Analysis." *Risk Analysis VI, Simulation and Hazard Mitigation.* C.A. Brebbia and E. Beriatos, eds. Southampton, U.K.: WIT Press, (2008):213-224.

Robinson, J. R. C. Personal Communication. Texas A&M University, Department of Agricultural Economics, January 2008.

Texas Agrilife Extension Service- Texas Crop and Livestock Budgets. November 1, 2006. Internet Site: http://agecoext.tamu.edu/?id=964 (Accessed October 17, 2007).

Tomek, W. G. "Commodity Futures Prices as Forecasts." *Review of Agricultural Economics* 19(1997):22-44.

USDA-ERS, Economic Research Service- Farm and Commodity Policy: Program Provisions. October 8, 2006. Internet Site: http://www.ers.usda.gov/Briefing/FarmPolicy/ProgramProvisions.htm (Accessed October 17, 2007).

USDA-ERS, Economic Research Service- Briefing Rooms: Cotton. November 7, 2007. Internet Site: http://www.ers.usda.gov/Briefing/Cotton/ (Accessed April 2008).

USDA-NASS, National Agricultural Statistics Service- Texas District Map. Internet Site: http://www.nass.usda.gov/Statistics_by_State/Texas/Charts_&_Maps/distmap2.htm (Accessed March 17, 2008).

Wood, W. C., C. E. Shafer, and C. G. Anderson. "Frequency and Duration of Profitable Hedging Margins for Texas Cotton Producers, 1980-1986," *Journal of Futures Markets* 9(1989):519-528.

Zulauf, C.R., S.H. Irwin. "Market Efficiency and Marketing to Enhance Income of Crop Producers." *Review of Agricultural Economics* 20(Winter1998):321.

VITA

Name:	Christopher Patrick Elrod
Address:	Department of Agricultural Economics Texas A&M University 2124 TAMU College Station, TX 77843-2124
Email Address:	elro51@tamu.edu

Education:	B.S., Agribusiness, California Polytechnic University, San Luis Obispo, 2006 M.S., Agricultural Economics, Texas A&M University, 2008